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[TITLE OF INVENTION IN KOREAN] 유기전계 발광소자와 그 제조방법

[TITLE OF INVENTION IN ENGLISH] ORGANIC ELECTROLUMINESCENT DISPLAY DEVICE AND METHOD OF FABRICATING THE SAME

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[EXAMINATION REQUEST] Request

[PURPORT] We submit application as above under the article 42 of the Patent Act and request of examination as above under the article 60.

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[FEES]

[BASIC APPLICATION FEE]	20 pages	29,000	Won
[ADDITIONAL APPLICATION FEE]	29 pages	29,000	Won
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[ENCLOSED] 1. Abstract, Specifications (with Drawings) - 1 set

[DOCUMENT OF ABSTRACT]

[ABSTRACT]

The present invention relates to an organic electroluminescent display (OELD) device, more particularly, to an OELD device that embodies a high resolution and a high aperture ratio and have an excellent color purity.

An OELD device according to a first embodiment of the present invention includes a thin film transistor (TFT) array part and an emission part that are formed on first and second substrates, respectively. Here, the emission part includes a white emitting layer and a color filter layer.

An OELD device according to a second embodiment of the present invention includes an organic electroluminescent layer emitting red, green and blue colors as well as the color filter layer.

The organic electroluminescent layer according to the first and second embodiments can display a color having a high color purity, further, embody the high aperture ratio.

[REPRESENTATIVE FIGURE]

FIG. 4

[SPECIFICATIONS]

[NAME OF INVENTION]

ORGANIC ELECTROLUMINESCENT DISPLAY DEVICE AND METHOD OF FABRICATING THE SAME

[BRIEF EXPLANATION OF FIGURES]

FIG. 1 is a schematic cross sectional view of an organic electroluminescent display (OELD) device according to the related art.

FIG. 2 is a schematic plan view of one pixel of a thin film transistor (TFT) array part of an OELD device according to the related art.

FIG. 3 is a cross sectional view taken along a line III-III' of FIG. 2.

FIG. 4 is a schematic cross-sectional view showing an OELD device according to a first embodiment of the present invention.

FIGs. 5a to 5c are schematic cross-sectional views showing a fabricating process of a TFT array part for an OELD device according to a first embodiment of the present invention.

FIGs. 6a to 6c are schematic cross-sectional views showing a fabricating process of an emission part for an OELD device according to a first embodiment of the present invention.

FIG. 7 is a schematic cross-sectional view of an OELD device according to a second embodiment of the present invention.

FIGs. 8a to 8c are schematic cross-sectional views showing a fabricating process of an emission part for an OELD device according to a second embodiment of the present invention.

FIG. 9 is a schematic cross-sectional view of an OELD device according to a third embodiment of the present invention.

FIGs. 10a to 10c are schematic cross-sectional views showing a fabricating process of an emission part and a TFT part for OELD device according to a third embodiment of the present invention.

FIGs. 11a and 11b are schematic cross-sectional views showing a fabricating process of a color filter substrate for OELD device according to a third embodiment of the present invention.

FIG. 12 is a schematic cross-sectional view of OELD device according to a fourth embodiment of the present invention.

FIGs. 13a to 13c are schematic cross-sectional views showing a fabricating process of an emission part for OELD device according to a fourth embodiment of the present invention.

FIG. 14 is a schematic cross-sectional view of OELD device according to a fifth embodiment of the present invention.

FIGs. 15a to 15c are schematic cross-sectional views showing a fabricating process of an emission part for OELD device according to a fifth embodiment of the present invention.

< EXPLANATION OF MAJOR PARTS IN FIGURES >

100: first substrate
124: connection electrode

200: second substrate
202: TFT

204a, 204b and 204c: red, green and blue sub-color filters

206: planarization layer
208: first electrode

210: organic electroluminescent layer

[DETAILED DESCRIPTION OF INVENTION]

[OBJECT OF INVENTION]

[TECHNICAL FIELD OF THE INVENTION AND PRIOR ART OF THE FIELD]

The present invention relates to an organic electroluminescent display (OELD) device, and more particularly, to an OELD device that has high color purity, high resolution, with an improved production yield, and a fabricating method thereof.

Generally, OELD devices have electron-input electrode that is commonly referred to as a cathode and hole-input electrode that is commonly referred to as an anode. The electrons and the holes are input into an electroluminescent layer from the cathode and anode, respectively, wherein the electron and hole together form an exciton. The OELD device emits light when the exciton is reduced from an excited state level to a ground state level. Accordingly, since OELD devices do not require additional light sources, both volume and weight of the OELD devices may be reduced. In addition, the OELD devices are advantageous because of their low power consumption, high luminance, fast response time, and low weight. Presently, the OELD devices are commonly implemented in mobile telecommunication terminals, car navigation systems (CNSs), personal digital assistants (PDAs), camcorders, and palm computers. In addition, since manufacturing processes for the OELD devices are simple, manufacturing costs can be reduced as compared to liquid crystal display (LCD) devices.

The OELD devices may be classified into passive matrix-type and active matrix-type. Though the passive matrix-type OELD devices have simple structures and manufacturing processes are simple, they require high power consumption and are not suitable for large-sized display devices. In addition, aperture ratios decrease as the number of electro lines increase. On the other hand, the active matrix-type OELD devices have high light-emitting efficiency and high image display quality.

FIG. 1 is a schematic cross sectional view of an organic electroluminescent display (OELD) device according to the related art.

In FIG. 1, the OELD device 10 has a transparent first substrate 12, a thin film transistor (TFT) array part 14, a first electrode 16, an organic electroluminescent layer 18, and a second electrode 20, wherein the TFT array part 14 is formed on the transparent first substrate 12. The first electrode 16, organic electroluminescent layer 18, and second electrode 20 are formed over the TFT array part 14. The organic electroluminescent layer 18 emits red (R), green (G), and blue (B) colored light, and it is commonly formed by patterning organic material separately in each pixel region "P" for the R, G and B colored light. A second substrate 28 has a moisture absorbent desiccant 22. The OELD device 10 is completed by bonding the first and second substrates 12 and 28 together by disposing a sealant 26 between the first and second substrates 12 and 28. The moisture absorbent desiccant 22 removes moisture and oxygen that may be infiltrated into an interior of the OELD device 10. The moisture absorbent desiccant 22 is formed by etching away a portion of the second substrate 28, filling the etched portion of the second substrate 28 with moisture absorbent desiccant material, and fixing the moisture absorbent desiccant material with a tape 25.

FIG. 2 is a schematic plan view of one pixel of a TFT array part of an OELD device according to the related art.

In FIG. 2, each of a plurality of pixel regions "P" defined on a substrate 12 includes a switching element "T_S," a driving element "T_D," and a storage capacitor "C_{ST}." The switching element "T_S" and the driving element "T_D" may be formed with combinations of more than two TFTs. The substrate 12 is formed of a transparent material, such as glass and plastic. A gate line 32 is formed along a first direction, and a data line 34 is formed along a

second direction perpendicular to the first direction. The data line 34 crosses the gate line perpendicularly with an insulating layer between the gate and data lines 32 and 34. A power line 35 is formed along the second direction, and is spaced apart from the data line 34. The TFT used for the switching element "T_S" has a switching gate electrode 36, a switching active layer 40, a switching source electrode 46, and a switching drain electrode 50, and the TFT for the driving element "T_D" has a driving gate electrode 38, a driving active layer 42, a driving source electrode 48, and a driving drain electrode 52. The switching gate electrode 36 is electrically connected to the gate line 32, and the switching source electrode 46 is electrically connected to the data line 34. The switching drain electrode 50 is electrically connected to the driving gate electrode 38 through a contact hole 54, and the driving source electrode 48 is electrically connected to the power line 35 through a contact hole 56. The driving drain electrode 52 is electrically connected to a first electrode 16 within the pixel region "P," wherein the power line 35 and a first capacitor electrode 15 that is formed of polycrystalline silicon layer form a storage capacitor "C_{ST}."

Hereinafter, a cross-sectional structure of a thin film transistor array part for an OELD device will be explained referring to FIG. 3.

FIG. 3 is a cross sectional view taken along a line III-III' of FIG. 2. In FIG. 3, only cross-sectional views of a driving element and an organic electroluminescent diode are illustrated.

As shown in FIG. 3, the OELD device has the driving element, i.e., a driving TFT "T_D" and an organic electroluminescent (EL) diode "E." The driving TFT "T_D" has a driving gate electrode 38, a driving active layer 42, a driving source electrode 56, and a driving drain electrode 52. A first electrode 16 is formed over the driving TFT "T_D" and is connected to the driving drain electrode 52 with an insulating layer between the first electrode

16 and the driving TFT "T_D." The organic EL diode "E" includes a first electrode 16, an organic electroluminescent (EL) layer 18, and a second electrode 20. The organic EL layer 18 is formed on the first electrode 16 for emitting light of a particular color wavelength, and the second electrode 20 is formed on the organic EL layer 18. A storage capacitor "C_{ST}" is connected in parallel to the driving TFT "T_D," and includes first and second capacitor electrodes 15 and 35. The driving source electrode 56 contacts the second capacitor electrode 35, i.e., a power line, and the first capacitor electrode 15 is formed of polycrystalline silicon material under the second capacitor electrode 35. The second electrode 20 is formed on the substrate 12 on which the driving TFT "T_D," the storage capacitor "C_{ST}," and the organic electroluminescent layer 18 are formed. The adjacent pixel regions may be divided by a sidewall.

OELD devices are classified into bottom emission type and top emission type according to a transparency of the first and second electrodes 16 and 20 of the organic EL diode "E." The bottom emission-type OELD devices are advantageous for their high image stability and variable fabrication processing due to encapsulation. However, the bottom emission-type OELD devices are not adequate for implementation in devices that require high resolution due to limitations of increased aperture ratio. On the other hand, since top emission-type OELD devices emit light upward of the substrate, the light can be emitted without influencing the TFT array part that is positioned under the organic electroluminescent (EL) layer. Accordingly, design of the TFT may be simplified. In addition, the aperture ratio can be increased, thereby increasing operational life span of the OELD device. However, since a cathode is commonly formed over the organic EL layer in the top emission-type OELD devices, material selection and light transmittance are limited such that light transmission efficiency is lowered. If a thin film-type passivation layer is formed to prevent

a reduction of the light transmittance, the thin film-type passivation layer may fail to prevent infiltration of exterior air into the device.

[TECHNICAL SUBJECT OF INVENTION]

The present invention is suggested to solve the above-mentioned problems. The present invention relates to a top emission type OELD device in which a TFT array part and an emission part are formed on respective substrates. Here, The present invention includes a first embodiment in which an organic EL layer emitting a white light and a color filter layer are disposed in the emission part, and a second embodiment including an organic EL layer emitting red, green and blue colored lights and a color filter layer.

Since the TFT array part and the emission part are formed on respective substrates according to the first and second embodiments, the problem such that a product yield of a panel for the OELD device is seriously limited by a product yield of the organic EL layer is solved. Further, another problems by defects due to particles or different factors when the organic EL layer is formed can be solved.

An advantage of the present invention is to provide an organic electroluminescent device that has improved production yield, high color purity, high aperture ratio, high resolution and high reliability.

[CONSTRUCTION AND OPERATION OF INVENTION]

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, an organic electroluminescent display device includes: first and second substrates facing and spaced apart from each other, the first and second substrates having a plurality of pixel regions; a switching element on an inner surface of the first substrate in each of the plurality of pixel regions, and a driving element

connected to the switching element; a connection electrode connected to the driving element; red, green and blue sub-color filters on an inner surface of the second substrate, each of the red, green and blue color filters corresponding to each of the plurality of pixel regions, and a black matrix on the inner surface of the second substrate at a boundary of each of the plurality of pixel regions; a first electrode on an entire surface of the red, green and blue sub-color filters and the black matrix; an organic electroluminescent layer on the first electrode; and a second electrode on the organic electroluminescent layer, the second electrode independently patterned in each of the plurality of pixel regions.

The first electrode includes one of a transparent conductive material group having indium-tin-oxide (ITO) and indium-zinc-oxide (IZO), and the second electrode includes at least one of calcium (Ca), aluminum (Al), magnesium (Mg), and lithium (Li).

The organic electroluminescent layer includes an organic material emitting white light, and the organic electroluminescent layer includes an organic material emitting red, green and blue colored lights corresponding to each of the red, green and blue color filters.

The organic electroluminescent layer includes a hole-transporting layer and an electron-transporting layer, further a sidewall is disposed on the first electrode corresponding to the black matrix.

Furthermore, a planarization layer is disposed between the black matrix and the first electrode and between the red, green and blue sub-color filters and the first electrode, the planarization layer including a transparent insulating material.

In another aspect, a method of fabricating an organic electroluminescent display device includes: preparing first and second substrates; defining a plurality of pixel regions in the first and second substrates; forming a switching element on an inner surface of the first substrate in each of the plurality of pixel regions, and forming a driving element connected to

the switching element; forming a connection electrode connected to the driving element and independently disposed in each of the plurality of the pixel regions; forming red, green and blue sub-color filters on the second substrate, each of the red, green and blue color filters corresponding to each of the plurality of pixel regions, and forming a black matrix on the second substrate at a boundary of each of the plurality of pixel regions; forming a first electrode on an entire surface of the red, green and blue sub-color filters and the black matrix; forming an organic electroluminescent layer on the first electrode; forming a second electrode on the organic electroluminescent layer, the second electrode independently disposed in each of the plurality of pixel regions; and attaching the first and second substrates so that the connection electrode could contact the second electrode.

The organic electroluminescent layer includes an organic material emitting white light, and the organic electroluminescent layer includes an organic material emitting red, green and blue colored lights corresponding to each of the red, green and blue color filters.

The organic electroluminescent layer includes a hole-transporting layer and an electron-transporting layer, further, a sidewall is disposed on the first electrode corresponding to the black matrix.

Furthermore, a planarization layer is disposed between the black matrix and the first electrode and between the red, green and blue sub-color filters and the first electrode, the planarization layer including a transparent insulating material.

In another aspect, an organic electroluminescent display device includes: first and second substrates facing and spaced apart from each other, the first and second substrates having a plurality of pixel regions; a switching element on an inner surface of the first substrate in each of the plurality of pixel regions, and a driving element connected to the switching element; a first electrode connected to the driving element, the first electrode

independently patterned in each of the plurality of pixel regions; an organic electroluminescent layer on the first electrode; a second electrode on the organic electroluminescent layer; red, green and blue sub-color filters on an inner surface of the second substrate, each of the red, green and blue color filters corresponding to each of the plurality of pixel regions; and a black matrix disposed between the red, green and blue sub-color filters.

The first electrode includes one of a transparent conductive material group having indium-tin-oxide (ITO) and indium-zinc-oxide (IZO), and the second electrode includes at least one of calcium (Ca), aluminum (Al), magnesium (Mg), and lithium (Li).

The organic electroluminescent layer includes an organic polymer material emitting red, green and blue colored lights corresponding to each of the red, green and blue color filters, and the organic electroluminescent layer includes a hole-transporting layer and an electron-transporting layer.

Further, a planarization layer is disposed between the black matrix and the first electrode and between the red, green and blue sub-color filters and the first electrode, the planarization layer including a transparent insulating material.

In another aspect, a method of fabricating an organic electroluminescent display device includes: preparing first and second substrates facing and spaced apart from each other, the first and second substrates having a plurality of pixel regions; forming a switching element on an inner surface of the first substrate in each of the plurality of pixel regions, and forming a driving element connected to the switching element; forming a first electrode connected to the driving element, the first electrode independently disposed in each of the plurality of pixel regions; forming an organic electroluminescent layer on the first electrode; forming a second electrode on the organic electroluminescent layer; forming red, green and

blue sub-color filters on an inner surface of the second substrate, each of the red, green and blue color filters corresponding to each of the plurality of pixel regions; and forming a black matrix disposed between the red, green and blue sub-color filters.

The organic electroluminescent layer is patterned with an organic polymer material emitting red, green and blue colored lights corresponding to each of the red, green and blue color filters.

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

Hereinafter, first and second embodiments relate to an OELD device including a color filter layer and an organic EL layer emitting white light.

- FIRST EMBODIMENT-

A first embodiment includes a feature that a TFT array part and an emission part are formed respective substrates, and the emission part includes a color filter layer and an organic EL layer emitting a white light.

FIG. 4 is a schematic cross-sectional view showing an OELD device according to a first embodiment of the present invention.

In FIG. 4, an OELD device 99 includes first and second substrates 100 and 200 face into and are spaced apart from each other. The first and second substrates 100 and 200 are attached with a sealant 250. The first and second substrates 100 and 200 have a plurality of pixel regions "P." Switching and driving thin film transistors (TFTs) "T" and array lines (not shown) are formed on an inner surface of the first substrate 100 in each pixel region "P." A connection electrode 124 contacts the driving TFT "T."

A black matrix 202 and red (R), green (G) and blue (B) sub-color filters 204a, 204b and 204c are formed on an inner surface of the second substrate 200. The red, green and

blue sub-color filters 204a, 204b and 204c correspond to each pixel region "P," and the black matrix 202 is disposed at a boundary of each pixel region "P." A planarization layer (an overcoat layer) 206 is formed on the black matrix 202 and the red, green and blue sub-color filters 204a, 204b and 204c, and a first electrode 208 of a transparent conductive material is formed on the planarization layer 206. An organic EL layer 210 is formed on the first electrode 208 and a second electrode 212 is formed on the organic EL layer 210 at each pixel region "P." The second electrode 212 contacts the connection electrode 124 of the first substrate 100.

In the above structure, the organic EL layer 210 and the second electrode 212 may be independently formed in each pixel region "P" by using a shadow mask. Since white light emitted from the organic EL layer 210 displays colors through the red, green and blue sub-color filters 204a, 204b and 204c, images having high color purity can be obtained. Moreover, high aperture ratio can be obtained because the OELD device 99 is a top emission type. In addition, since the emission part including the organic EL layer 210 and the first and second electrodes 208 and 212 is not formed on the TFT array part, production yield can be improved.

Hereinafter, referring to FIGs. 5A to 5C, a manufacturing process of a TFT array part for an OELD device according to the first embodiment will be explained.

FIGs. 5a to 5c are schematic cross-sectional views showing a fabricating process of a TFT array part for an OELD device according to a first embodiment of the present invention.

In FIG. 5a, a first insulating layer (a buffer layer) 102 is formed on a first substrate 100 having a plurality of pixel regions "P" by depositing one of inorganic insulating material group including silicon nitride (SiN_x) and silicon oxide (SiO_2). After forming amorphous silicon (a-Si:H) layer (not shown) on the first insulating layer 102, the amorphous silicon

layer is crystallized to be a polycrystalline silicon layer (not shown). A dehydrogenation process can be performed before the crystallization process, and the crystallization process can be performed by using heat or light. An active layer 104 is obtained by patterning the polycrystalline silicon layer. The active layer 104 defines a first active region 104a and two second active region 104b at both sides of the first region 104a. A gate insulating layer 106 as a second insulating layer is formed on the active layer 104 by depositing one of an inorganic insulating material group including silicon nitride (SiN_x) and silicon oxide (SiO_2). The gate insulating layer 106 may be formed on an entire surface of the first substrate 100 without any subsequent etch process, or may be etched to have the same shape as a gate electrode 108 after forming the gate electrode 108.

After forming a gate electrode 108 on the gate insulating layer 106 over the active layer 104, the two second active regions 104b of the active layer 104 are doped with impurities such as boron (B) or phosphorous (P). An interlayer insulating layer 110 as a third insulating layer having first and second contact holes 112 and 114 is formed on the gate electrode 108. The first and second contact holes 112 and 114 expose the two second active regions 104b of the active layer 104, respectively. The gate electrode 108 may be made of one of a conductive metallic material group including aluminum (Al), aluminum (Al) alloy, copper (Cu), tungsten (W), tantalum (Ta) and molybdenum (Mo). The interlayer insulating layer 110 may be made of one of the mentioned insulating material group.

In FIG. 5b, source and drain electrodes 116 and 118 are formed on the interlayer insulating layer 110 by depositing and patterning a second metal layer. The source and drain electrodes 116 and 118 are connected to the two second active regions 104b of the active layer 104, respectively. A passivation layer 120 as a fourth insulating layer is formed on the source and drain electrodes 116 and 118 by depositing one of the mentioned inorganic

insulating material group and an organic insulating material group including benzocyclobutene (BCB) and acrylic resin. The passivation layer 120 has a drain contact hole 122 exposing the drain electrode 118.

Next, in FIG. 5c, a connection electrode 124 contacting the drain electrode 118 is formed in each pixel region "P."

Through this process, a TFT array substrate can be manufactured in accordance with the first embodiment of the present invention.

Even though the driving TFT is a polycrystalline silicon TFT having a coplanar structure, the driving TFT can be made of amorphous silicon in another embodiment. Although a TFT of amorphous silicon is various, an inverted staggered type TFT may be suggested as a typical TFT.

FIGs. 6a to 6c are schematic cross-sectional views showing a fabricating process of an emission part for an OELD device according to a first embodiment of the present invention.

In FIG. 6a, a black matrix 202 is formed on a second substrate 200 having a plurality of pixel regions "P." The black matrix 202 is disposed at a boundary of each pixel region "P."

In FIG. 6b, red(R), green (G) and blue (B) sub color filters 204a, 204b and 204c are formed on the second substrate 200. Each sub color filter 204a, 204b or 204c is disposed in the pixel region "P." A planarization layer (an overcoat layer) 206 is formed on the black matrix 202 and the red, green and blue sub-color filters 204a, 204b and 204c by coating one of an organic insulating material group including benzocyclobutene (BCB) and acrylic resin.

Next, in FIG. 6c, a first electrode 208 is formed on the planarization layer 206 and an organic electroluminescent (EL) layer 210 emitting white light is formed on the first electrode 208. A second electrode 212 is formed on the organic EL layer 210 in each pixel region "P."

The first electrode 208 may be made of one of a transparent conductive metallic material group including indium-tin-oxide (ITO) and indium-zinc-oxide (IZO). The organic EL layer 210 can be formed of a single layer or a multiple layer. In case of a multiple layer, the organic EL layer 210 may include a hole-transporting layer 210b on the first electrode 208, an emission layer 210a on the hole-transporting layer 210b and an electron-transporting layer 210c on the emission layer 210a. The organic EL layer 210 and the second electrode 212 may be independently formed in each pixel region "P" by using a shadow mask. The second electrode 212 may be a single layer made of one of aluminum (Al), calcium (Ca) and magnesium (Mg) or may be a double layer of lithium fluorine/aluminum (LiF/Al).

Through this process, the emission part for the OELD device according to the first embodiment of the present invention can be manufactured. Specifically, an active matrix type OELD device according to the first embodiment of the present invention can be manufactured by attaching the TFT array part and the emission part as explained above processes.

Hereinafter, a modified embodiment from the first embodiment according to the present invention will be explained through following a second embodiment.

- SECOND EMBODIMENT –

A second embodiment has a feature that a sidewall is formed at boundaries between pixel regions so as not to use a shadow mask when a second electrode is formed with respect to a double plate type OELD device.

FIG. 7 is a schematic cross-sectional view of an OELD device according to a second embodiment of the present invention.

In FIG. 7, an OELD device 299 includes first and second substrates 300 and 400 face into and are spaced apart from each other. The first and second substrates 300 and 400 are

attached with a sealant 350. The first and second substrates 300 and 400 have a plurality of pixel regions "P." Switching and driving TFTs "T" and array lines (not shown) are formed on an inner surface of the first substrate 300 in each pixel region "P." A connection electrode 224 contacts the driving TFT "T.

A black matrix 402 and red (R), green (G) and blue (B) sub-color filters 404a, 404b and 404c are formed on an inner surface of the second substrate 400. The red, green and blue sub-color filters 404a, 404b and 404c correspond to each pixel region "P," and the black matrix 402 is disposed at a boundary of each pixel region "P." A planarization layer (an overcoat layer) 406 is formed on the black matrix 402 and the red, green and blue sub-color filters 404a, 404b and 404c, and a first electrode 408 of a transparent conductive material is formed on the planarization layer 406. Sequentially, a sidewall 410 corresponding to the boundary of each pixel region "P" is formed on the first electrode 408. An organic EL layer 412 emitting white light is independently formed on the first electrode 408 in the sidewall 410 of each pixel region "P." A second electrode 414 is independently formed on the organic EL layer 412 at each pixel region "P." Since the organic EL layer 412 and the second electrode 414 are independently formed in each pixel region "P" by using the sidewall 410, it is not necessary to use a shadow mask.

Since a fabricating process of a first substrate having a TFT array part for an organic electroluminescent device according to a second embodiment is similar to that according to a first embodiment as shown in FIG. 5a to 5c, only a fabricating process of a second substrate having an organic electroluminescent diode for an organic electroluminescent device according to a second embodiment will be illustrated referring to Figs. 8a to 8c.

FIGs. 8a to 8c are schematic cross-sectional views showing a fabricating process of a emission part for an OELD device according to a second embodiment of the present invention.

In FIG. 8a, a black matrix 402 is formed on a second substrate 400 having a plurality of pixel regions "P." The black matrix 402 is disposed at a boundary of each pixel region "P."

In FIG. 8b, red, green and blue sub-color filters 404a, 404b and 404c are formed on the second substrate 400. Each sub color filter 404a, 404b or 404c is disposed in each pixel region "P." A planarization layer (an overcoat layer) 406 is formed on the black matrix 402 and the red, green and blue sub-color filters 404a, 404b and 404c by coating one of an organic insulating material group including benzocyclobutene (BCB) and acrylic resin.

In FIG. 8c, a first electrode 408 is formed on the planarization layer 406. A sidewall 410 corresponding to the boundary of each pixel region "P" is formed on the first electrode 408. The sidewall 410 may be made of one of photoresist and a transparent organic material. An organic electroluminescent (EL) layer 412 emitting white light is formed on the first electrode 408 in the sidewall 410 of each pixel region "P." A second electrode 414 is formed on the organic EL layer 412 in each pixel region "P." The first electrode 408 may be made of one of a transparent conductive metallic material group including indium-tin-oxide (ITO) and indium-zinc-oxide (IZO). The organic EL layer 412 can be formed of a single layer or a multiple layer. In case of a multiple layer, the organic EL layer 412 may include a hole-transporting layer 412b on the first electrode 408, an emission layer 412a on the hole-transporting layer 412b and an electron-transporting layer 412c on the emission layer 412a. The second electrode 414 may be a single layer made of one of aluminum (Al), calcium (Ca) and magnesium (Mg) or may be a double layer of lithium fluorine/aluminum (LiF/Al).

Through this processes, the emission part for the OELD according to the second embodiment of the present invention can be manufactured. Specifically, an active matrix type OELD device according to the second embodiment of the present invention can be

manufactured by attaching the TFT array part and the emission part manufactured through the mentioned processes.

Hereinafter, an OELD device including sub-color filters and an organic EL layer emitting the same light as the color filter layer as corresponding to the respective sub-color filters will be explained in accordance with third to fifth embodiments.

- THIRD EMBODIMENT –

A third embodiment according to the present invention includes an OELD device having a first substrate having a TFT array part and an emission part emitting red, green and blue colored lights and a second substrate having a color filter layer(red, green and blue sub-color filters) including the same color to the emission part corresponding to the emission part.

FIG. 9 is a schematic cross-sectional view of an OELD device according to a third embodiment of the present invention.

In FIG. 9, an OELD device 499 includes first and second substrates 500 and 600 face into and are spaced apart from each other. The first and second substrates 500 and 600 are attached with a sealant 550. The first and second substrates 500 and 600 have a plurality of pixel regions "P." Switching and driving thin film transistors (TFTs) "T" and array lines (not shown) are formed on an inner surface of the first substrate 500 in each pixel region "P." A first electrode 524 contacting the driving TFT "T" is formed in each pixel region "P" and an organic electroluminescent (EL) layer 526 is formed on the first electrode 524. The organic EL layer 526 emits red, green and blue colored light in each pixel region "P." A second electrode 528 is formed on the organic EL layer 526. The second electrode 528 may be made of an opaque conductive material such as aluminum (Al) and chromium (Cr). To obtain a top emission type OELD device, the second electrode 528 of opaque conductive

material is formed to have a thickness of about several tens Å for light transparency. An additional transparent electrode (not shown) may be formed on the thin second electrode 528.

A black matrix 602 and red, green and blue sub-color filters 604a, 604b and 604c are formed on an inner surface of the second substrate 600. The red, green and blue sub-color filters 404a, 404b and 404c correspond to each pixel region "P," and the black matrix 602 is disposed at a boundary of each pixel region "P." A planarization layer (an overcoat layer) 606 is formed on the black matrix 602 and the red, green and blue sub-color filters 404a, 404b and 404c.

The OELD device according to the present invention has an organic polymer layer independently patterned and emitting red, green and blue colored lights in the emission part. A color filter layer including red, green and blue sub-color filters transmitting the red, green and blue colored lights formed on an opposite substrate, thereby obtaining high color purity.

Hereinafter, a method of fabricating the OELD device will be explained in accordance with the third embodiment referring to figures.

FIGs. 10a to 10c are schematic cross-sectional views showing a fabricating process of an emission part and a TFT part for OELD device according to a third embodiment of the present invention.

In FIG. 10a, a buffer layer 502 as a first insulating layer is formed on a first substrate 500 having a plurality of pixel regions "P" by depositing one of inorganic insulating material group including silicon nitride (SiN_x) and silicon oxide (SiO_2). After forming amorphous silicon (a-Si:H) layer (not shown) on the first insulating layer 502, the amorphous silicon layer is crystallized to be a polycrystalline silicon layer (not shown). An active layer 504 including a first active region 504a, and two second active regions 504b at both sides of the first active region 504a is obtained by patterning the polycrystalline silicon layer. A

dehydrogenation process can be performed before the crystallization process, and the crystallization process can be performed by using heat or light. A gate insulating layer 506 as a second insulating layer is formed on the active layer 504 by depositing one of an inorganic insulating material group including silicon nitride (SiN_x) and silicon oxide (SiO_2). The second insulating layer 506 may be formed on an entire surface of the first substrate 500 without any subsequent etch process, or may be etched to have the same shape as a gate electrode 508 after forming the gate electrode 508.

After forming a gate electrode 508 on the second insulating layer 506 over the active layer 504, the two second active regions 504b of the active layer 504 are doped with impurities such as boron (B) or phosphorous (P). An interlayer insulating layer 510 as a third insulating layer having first and second contact holes 512 and 514 is formed on the gate electrode 508. The first and second contact holes 512 and 514 expose the two second active regions 504b of the active layer 504, respectively. The gate electrode 508 may be made of one of a conductive metallic material group including aluminum (Al), aluminum (Al) alloy, copper (Cu), tungsten (W), tantalum (Ta) and molybdenum (Mo). The interlayer insulating layer 510 may be made of one of the mentioned inorganic insulating material group.

In FIG. 10b, source and drain electrodes 516 and 518 are formed on the interlayer insulating layer 510 by depositing and patterning a second meal layer. The source and drain electrodes 516 and 518 are connected to the two second active regions 504b of the active layer 504, respectively. A passivation layer 520 as a fourth insulating layer is formed on the source and drain electrodes 516 and 518 by depositing one of the mentioned inorganic insulating material group and an organic insulating material group including benzocyclobutene (BCB) and acrylic resin. The passivation layer 520 has a drain contact hole 522 exposing the drain electrode 518.

FIG. 10 is a view showing a process forming an emission part in the TFT array part manufactured by the mentioned process.

In FIG. 10c, a first electrode 524 connected to the drain electrode 518 exposed by the drain contact hole 522. The first electrode 524 may be made of a transparent conductive material having high work function such as indium-tin-oxide (ITO) and indium-zinc-oxide (IZO). An organic EL layer 526 is formed on the first electrode 524. The organic EL layer 526 can be formed of a single layer or a multiple layer. In case of a multiple layer, the organic EL layer 526 may include a hole-transporting layer 526b on the first electrode 524, an emission layer 526a on the hole-transporting layer 526b and an electron-transporting layer 526c on the emission layer 526a. A second electrode 528 as a cathode electrode is formed on the organic EL layer 526. When the second electrode 528 is made of an opaque conductive material such as aluminum (Al) and chromium (Cr), the second electrode 528 may be formed to have a thickness of about several tens Å for light transparency. Moreover, an additional transparent electrode (not shown) may be formed on the thin second electrode 528 to improve hardness of the second electrode 528.

Hereinafter, FIGs. 11a and 11b are view showing a process forming a color filter substrate.

FIGs. 11a and 11b are schematic cross-sectional views showing a fabricating process of a color filter substrate for OELD device according to a third embodiment of the present invention.

In FIG. 11a, a black matrix 602 is formed on a second substrate 600 having a plurality of pixel regions "P." The black matrix 602 is disposed at a boundary of each pixel region "P."

In FIG. 11b, red, green and blue sub-color filters 604a, 604b and 604c are formed on the second substrate 600. Each sub-color filter 604a, 604b or 604c is disposed in the pixel region "P." A planarization layer (an overcoat layer) 606 is formed on the black matrix 602 and the sub-color filter 604a, 604b or 604c by coating one of an organic insulating material group including benzocyclobutene (BCB) and acrylic resin. A passivation layer 608 may be formed on the planarization layer 606.

Through this process, the color filter substrate can be manufactured. Specifically, an active-matrix type OELD device can be manufactured by attaching the color filter substrate and an opposite substrate having the TFT array part and the emission part.

Hereinafter, a modified embodiment of the third embodiment will be explained through a fourth embodiment.

- FOURTH EMBODIMENT -

FIG. 12 is a schematic cross-sectional view of OELD device according to a fourth embodiment of the present invention.

In FIG. 12, an OELD device 640 includes first and second substrates 650 and 700 face into and are spaced apart from each other. The first and second substrates 650 and 700 are attached with a sealant 730. The first and second substrates 650 and 700 have a plurality of pixel regions "P." Switching and driving thin film transistors (TFTs) "T" and array lines (not shown) are formed on an inner surface of the first substrate 650 in each pixel region "P." A connection electrode 674 contacts the driving TFT "T.

A black matrix 702 and red (R), green (G) and blue (B) sub-color filters 704a, 704b and 704c are formed on an inner surface of the second substrate 700. The red, green and blue sub-color filters 704a, 704b and 704c correspond to each pixel region "P," and the black matrix 702 is disposed at a boundary of each pixel region "P." A planarization layer (an

overcoat layer) 706 is formed on the black matrix 702 and the red, green and blue sub-color filters 704a, 704b and 704c, and a first electrode 708 is formed on the planarization layer 706. An organic EL layer 710 is formed on the first electrode 708. The organic EL layer 710 may be formed by using a shadow mask to emit one of red, green and blue colored lights corresponding to the sub color filter 704a, 704b or 704c in each pixel region "P." A second electrode 712 is independently formed on the organic EL layer 710 at each pixel region "P."

Hereinafter, a method of fabricating an emission part for an OELD device according to the fourth embodiment will be explained referring to figures.

FIGs. 13a to 13c are schematic cross-sectional views showing a fabricating process of an emission part for OELD device according to a fourth embodiment of the present invention.

In FIG. 13a, a black matrix 702 is formed on a second substrate 700 having a plurality of pixel regions "P." The black matrix 702 is disposed at a boundary of each pixel region "P."

In FIG. 13b, red, green and blue sub-color filters 704a, 704b and 704c are formed on the second substrate 700. Each sub color filter 704a, 704b or 704c is disposed in each pixel region "P." A planarization layer (an overcoat layer) 706 is formed on the black matrix 702 and the red, green and blue sub-color filters 704a, 704b and 704c by coating one of an organic insulating material group including benzocyclobutene (BCB) and acrylic resin.

In FIG. 13c, a first electrode 708 is formed on the planarization layer 706. An organic electroluminescent (EL) layer 710 is formed on the first electrode 708 in each pixel region "P." The organic EL layer 710 may be formed to emit one of red, green and blue colored lights corresponding to the sub color filter 704a, 704b or 704c. A second electrode 712 is formed on the organic EL layer 710 in each pixel region "P." The first electrode 708 may be made of one of a transparent conductive metallic material group including indium-tin-

oxide (ITO) and indium-zinc-oxide (IZO). The organic EL layer 710 can be formed of a single layer or a multiple layer. In case of a multiple layer, the organic EL layer 710 may include a hole-transporting layer 710b on the first electrode 708, an emission layer 710a on the hole-transporting layer 710b and an electron-transporting layer 710c on the emission layer 710a. The second electrode 712 may be a single layer made of one of aluminum (Al), calcium (Ca) and magnesium (Mg) or may be a double layer of lithium fluorine/aluminum (LiF/Al).

Through this process, the emission part for the OELD device according to the fourth embodiment of the present invention can be manufactured. The OELD device can be manufactured by attaching the mentioned TFT array part and the emission part.

- FIFTH EMBODIMENT -

A fifth embodiment according to the present invention has a sidewall is formed along boundaries between the plurality of pixel regions.

FIG. 14 is a schematic cross-sectional view of OELD device according to a fifth embodiment of the present invention.

In FIG. 14, an OELD device 799 includes first and second substrates 800 and 900 face into and are spaced apart from each other. The first and second substrates 800 and 900 are attached with a sealant 850. The first and second substrates 800 and 900 have a plurality of pixel regions "P." Switching and driving thin film transistors (TFTs) "T" and array lines (not shown) are formed on an inner surface of the first substrate 800 in each pixel region "P." A connection electrode 824 contacts the driving TFT "T.

A black matrix 902 and red, green and blue sub-color filters 904a, 904b and 904c are formed on an inner surface of the second substrate 900. The red, green and blue sub-color filters 904a, 904b and 904c correspond to each pixel region "P," and the black matrix 902 is

disposed at a boundary of each pixel region "P." A planarization layer (an overcoat layer) 906 is formed on the black matrix 902 and the red, green and blue sub-color filters 904a, 904b and 904c, and a first electrode 908 of a transparent conductive material is formed on the planarization layer 906. A sidewall 910 corresponding to the boundary of each pixel region "P" is formed on the first electrode 908. An organic EL layer 912 emitting white light is independently formed on the first electrode 908 in the sidewall 910 of each pixel region "P." A second electrode 914 is independently formed on the organic EL layer 912 at each pixel region "P." Since the organic EL layer 912 and the second electrode 914 are independently formed in each pixel region "P" by using the sidewall 910, it is not necessary to use a shadow mask.

Here, the process forming the TFT array part is already explained through the first embodiment, for convenience sake, so the descriptions are omitted.

Hereinafter, a process of an emission part according to the fifth embodiment of the present invention will be explained.

FIGs. 15a to 15c are schematic cross-sectional views showing a fabricating process of an emission part for OELD device according to a fifth embodiment of the present invention.

In FIG. 15a, a black matrix 902 is formed on a second substrate 900 having a plurality of pixel regions "P." The black matrix 902 is disposed at a boundary of each pixel region "P."

In FIG. 15b, red, green and blue sub-color filters 904a, 904b and 904c are formed on the second substrate 900. Even though not shown in FIG. 15B, the red, green and blue sub-color filters 904a, 904b and 904c can be formed to cover the black matrix 902. Each sub color filter 904a, 904b or 904c is disposed in each pixel region "P." A planarization layer (an overcoat layer) 906 is formed on the black matrix 902 and the color filter layer 904 by

coating one of an organic insulating material group including benzocyclobutene (BCB) and acrylic resin.

In FIG. 15c, a first electrode 908 is formed on the planarization layer 906. A sidewall 910 corresponding to the boundary of each pixel region "P" is formed on the first electrode 908. The sidewall 910 may be made of one of photoresist and a transparent organic material. An organic EL layer 912 emitting one of red, green and blue colored lights is formed on the first electrode 908 in the sidewall 910 of each pixel region "P." A second electrode 914 is formed on the organic EL layer 912 in each pixel region "P." The first electrode 908 may be made of one of a transparent conductive metallic material group including indium-tin-oxide (ITO) and indium-zinc-oxide (IZO). The organic EL layer 912 can be formed of a single layer or a multiple layer. In case of a multiple layer, the organic EL layer 912 may include a hole-transporting layer 912b on the first electrode 908, an emission layer 912a on the hole-transporting layer 912b and an electron-transporting layer 912c on the emission layer 912a. The second electrode 914 may be a single layer made of one of aluminum (Al), calcium (Ca) and magnesium (Mg) or may be a double layer of lithium fluorine/aluminum (LiF/Al).

Through this process, the emission part for the OELD device according to the second embodiment of the present invention can be manufactured. Specifically, an active matrix type OELD device according to the fifth embodiment of the present invention can be manufactured by attaching the mentioned TFT array part and the emission part.

As explained above, the OELD device and the method of fabricating the same are explained in accordance with the first to fifth embodiments. Through the embodiments, the present invention includes the emission part displaying red, green and blue colored lights by forming the organic EL layer emitting white light and the color filter layer, or forming the

color filter layer and the organic EL layer emitting red, green and blue colored lights. Therefore, the present invention has an advantage that color purity is improved.

[EFFECT OF INVENTION]

An organic electroluminescent device of the present invention has some advantages. First, since the OELD device includes both of a color filter layer and an organic EL layer, color purity is improved. Second, since the OELD device is a top emission type, a thin film transistor can be easily designed, and high resolution and high aperture ratio can be obtained regardless of lower array patterns. Third, since array patterns and an emission part are formed on the respective substrate, influences affecting the TFT during forming the emission part cannot be considered. Therefore, there is an effect that production yield can be improved.

[RANGE OF CLAIMS]

[CLAIM 1]

An organic electroluminescent display device, comprising:

first and second substrates facing and spaced apart from each other, the first and second substrates having a plurality of pixel regions;

a switching element on an inner surface of the first substrate in each of the plurality of pixel regions, and a driving element connected to the switching element;

a connection electrode connected to the driving element;

red, green and blue sub-color filters on an inner surface of the second substrate, each of the red, green and blue color filters corresponding to each of the plurality of pixel regions, and a black matrix on the inner surface of the second substrate at a boundary of each of the plurality of pixel regions;

a first electrode on an entire surface of the red, green and blue sub-color filters and the black matrix;

an organic electroluminescent layer on the first electrode; and

a second electrode on the organic electroluminescent layer, the second electrode independently patterned in each of the plurality of pixel regions.

[CLAIM 2]

The device according to claim 1, wherein the first electrode includes one of a transparent conductive material group having indium-tin-oxide (ITO) and indium-zinc-oxide (IZO).

[CLAIM 3]

The device according to claim 1, wherein the second electrode includes at least one of calcium (Ca), aluminum (Al), magnesium (Mg), and lithium (Li).

[CLAIM 4]

The device according to claim 1, wherein the organic electroluminescent layer includes an organic material emitting white light.

[CLAIM 5]

The device according to claim 1, wherein the organic electroluminescent layer includes an organic material emitting red, green and blue colored lights corresponding to each of the red, green and blue color filters.

[CLAIM 6]

The device according to claim 1, wherein the organic electroluminescent layer includes a hole-transporting layer and an electron-transporting layer.

[CLAIM 7]

The device according to claim 1, further comprising a sidewall on the first electrode corresponding to the black matrix.

[CLAIM 8]

The device according to claim 1, further comprising a planarization layer between the black matrix and the first electrode and between the red, green and blue sub-color filters and the first electrode, the planarization layer including a transparent insulating material.

[CLAIM 9]

A method of fabricating an organic electroluminescent display device, comprising:

preparing first and second substrates;

defining a plurality of pixel regions in the first and second substrates;

forming a switching element on an inner surface of the first substrate in each of the plurality of pixel regions, and forming a driving element connected to the switching element;

forming a connection electrode connected to the driving element and independently disposed in each of the plurality of the pixel regions;

forming red, green and blue sub-color filters on the second substrate, each of the red, green and blue color filters corresponding to each of the plurality of pixel regions, and forming a black matrix on the second substrate at a boundary of each of the plurality of pixel regions;

forming a first electrode on an entire surface of the red, green and blue sub-color filters and the black matrix;

forming an organic electroluminescent layer on the first electrode;

forming a second electrode on the organic electroluminescent layer, the second electrode independently disposed in each of the plurality of pixel regions; and

attaching the first and second substrates so that the connection electrode could

contact the second electrode.

[CLAIM 10]

The method according to claim 9, wherein the organic electroluminescent layer includes an organic material emitting white light.

[CLAIM 11]

The method according to claim 9, wherein the organic electroluminescent layer includes an organic material emitting red, green and blue colored lights corresponding to each of the red, green and blue color filters.

[CLAIM 12]

The method according to claim 9, wherein the organic electroluminescent layer includes a hole-transporting layer and an electron-transporting layer.

[CLAIM 13]

The method according to claim 9, further comprising a sidewall on the first electrode corresponding to the black matrix.

[CLAIM 14]

The method according to claim 9, further comprising a planarization layer between the black matrix and the first electrode and between the red, green and blue sub-color filters and the first electrode, the planarization layer including a transparent insulating material.

[CLAIM 15]

An organic electroluminescent display device, comprising:

first and second substrates facing and spaced apart from each other, the first and second substrates having a plurality of pixel regions;

a switching element on an inner surface of the first substrate in each of the plurality of pixel regions, and a driving element connected to the switching element;

a first electrode connected to the driving element, the first electrode independently patterned in each of the plurality of pixel regions;

an organic electroluminescent layer on the first electrode;

a second electrode on the organic electroluminescent layer;

red, green and blue sub-color filters on an inner surface of the second substrate, each of the red, green and blue color filters corresponding to each of the plurality of pixel regions; and

a black matrix disposed between the red, green and blue sub-color filters.

[CLAIM 16]

The device according to claim 15, wherein the first electrode includes one of a transparent conductive material group having indium-tin-oxide (ITO) and indium-zinc-oxide (IZO).

[CLAIM 17]

The device according to claim 15, wherein the second electrode includes at least one

of calcium (Ca), aluminum (Al), magnesium (Mg), and lithium (Li).

[CLAIM 18]

The device according to claim 15, wherein the organic electroluminescent layer includes an organic polymer material emitting red, green and blue colored lights corresponding to each of the red, green and blue color filters.

[CLAIM 19]

The device according to claim 15, wherein the organic electroluminescent layer includes a hole-transporting layer and an electron-transporting layer.

[CLAIM 20]

The device according to claim 15, further comprising a planarization layer between the black matrix and the first electrode and between the red, green and blue sub-color filters and the first electrode, the planarization layer including a transparent insulating material.

[CLAIM 21]

A method of fabricating an organic electroluminescent display device, comprising:

preparing first and second substrates facing and spaced apart from each other, the first and second substrates having a plurality of pixel regions;

forming a switching element on an inner surface of the first substrate in each of the plurality of pixel regions, and forming a driving element connected to the

switching element;

forming a first electrode connected to the driving element, the first electrode independently disposed in each of the plurality of pixel regions;

forming an organic electroluminescent layer on the first electrode;

forming a second electrode on the organic electroluminescent layer;

forming red, green and blue sub-color filters on an inner surface of the second substrate, each of the red, green and blue color filters corresponding to each of the plurality of pixel regions; and

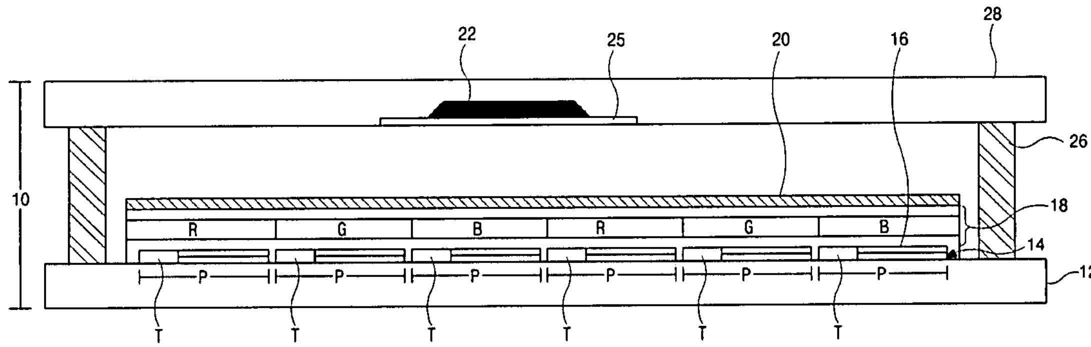
forming a black matrix disposed between the red, green and blue sub-color filters.

[CLAIM 22]

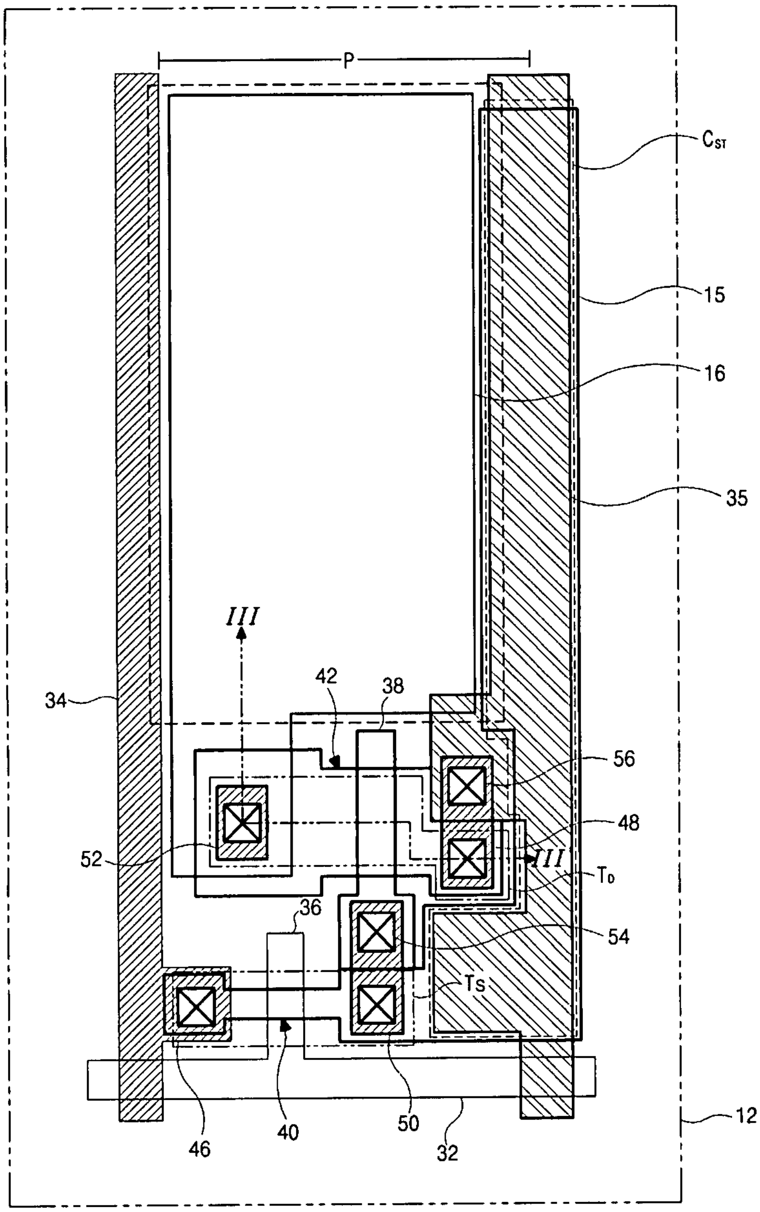
The method according to claim 21, wherein the organic electroluminescent layer is patterned with an organic polymer material emitting red, green and blue colored lights corresponding to each of the red, green and blue color filters.

[DRAWINGS]

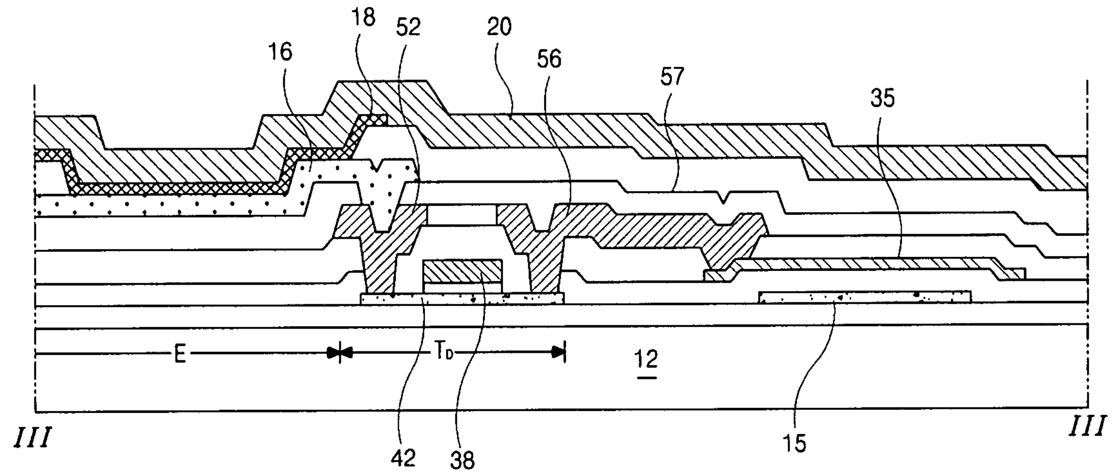
[FIG. 1]



[FIG. 2]

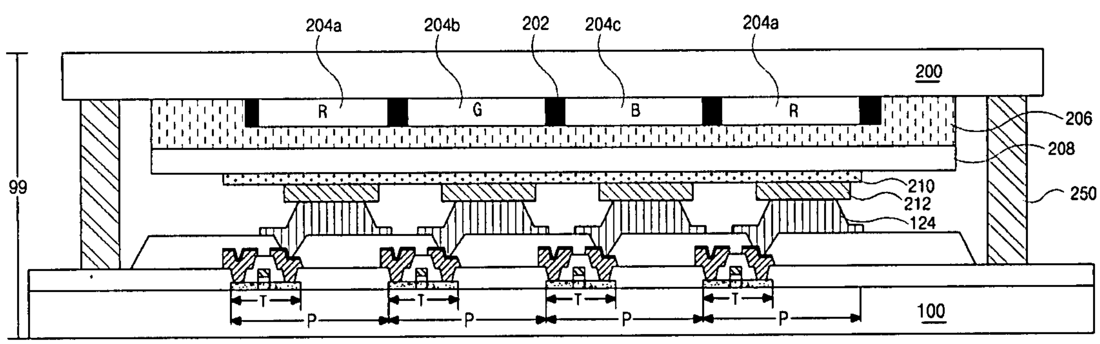


[FIG. 3]



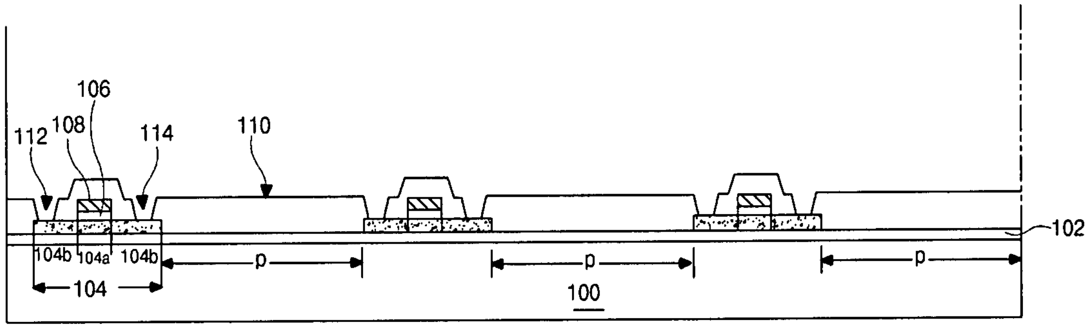
18
52
20
16
56
57
35
E
TD
12
III
III'
42
38
15

[FIG. 4]

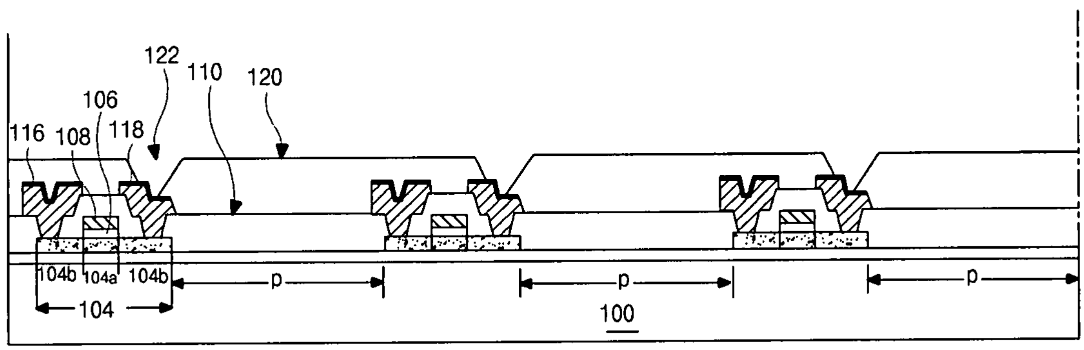


204a
204b
202
204c
204a
200
R
G
B
R
206
208
99
210
212
124
250
T
T
T
T
P
P
P
P
100

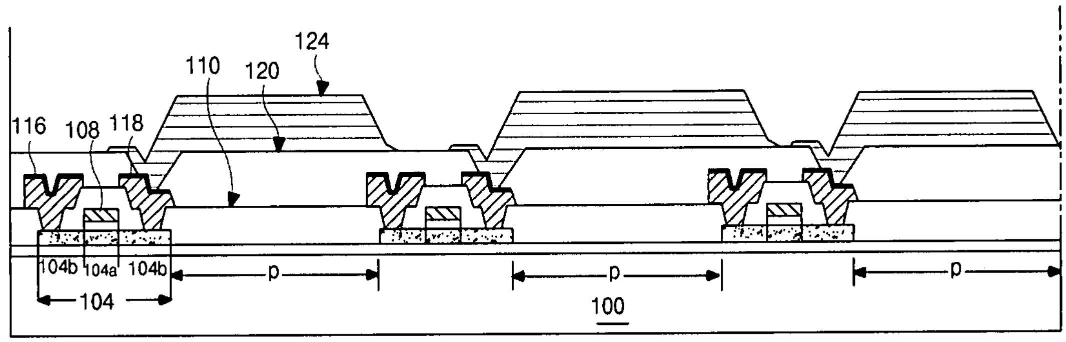
[FIG. 5a]



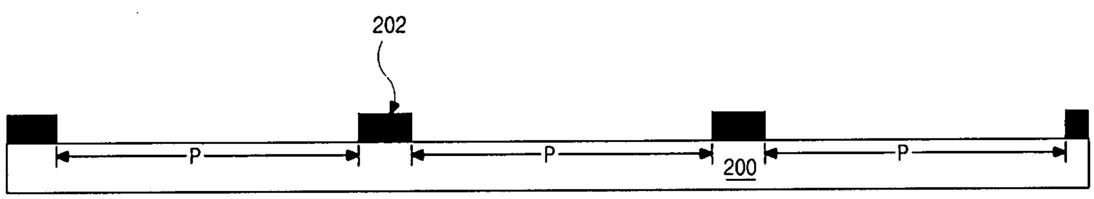
[FIG. 5b]



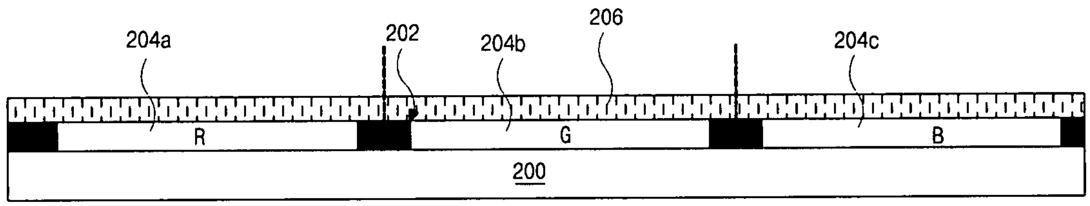
[FIG. 5c]



[FIG. 6a]

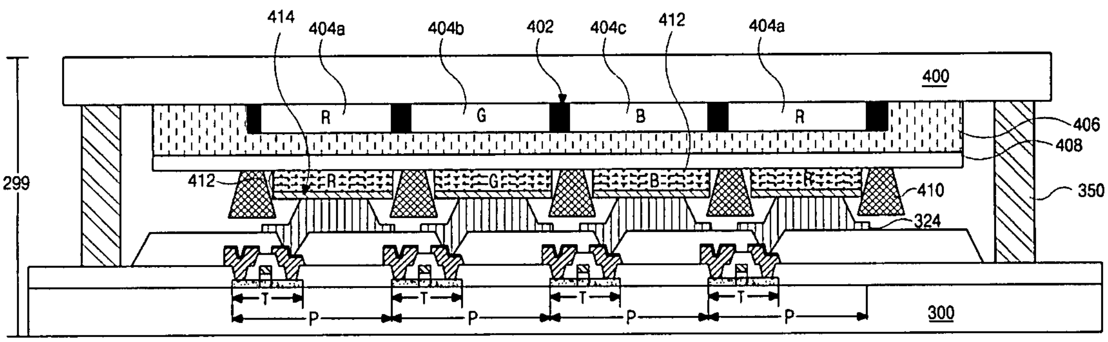


[FIG. 6b]

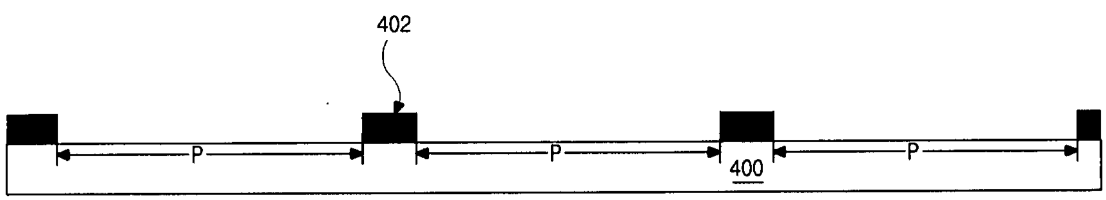


[FIG. 6c]

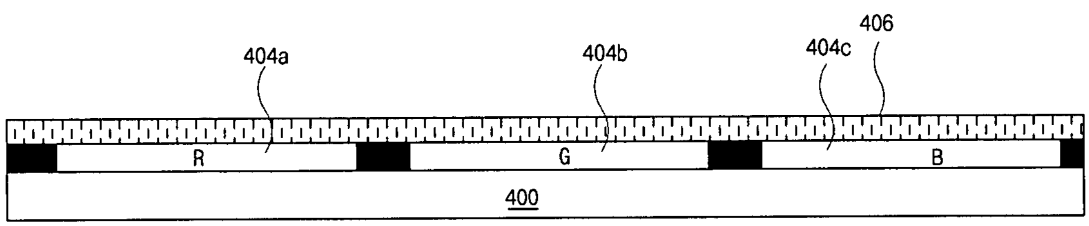
[FIG. 7]



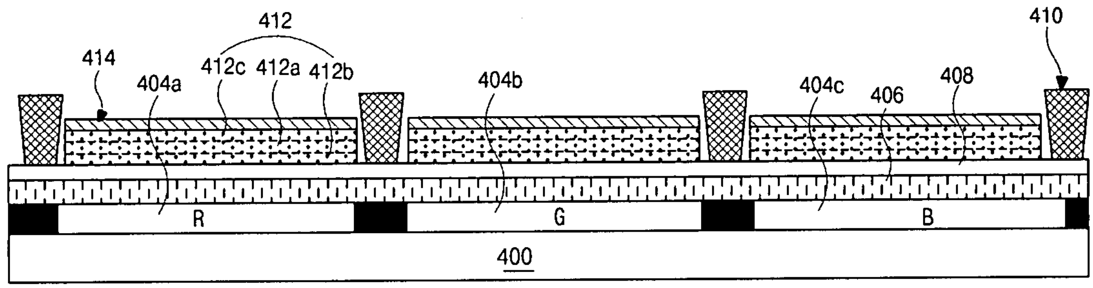
[FIG. 8a]



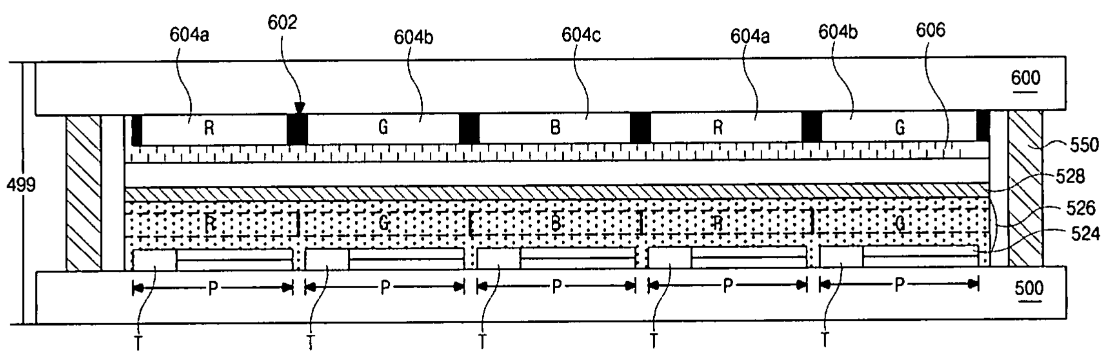
[FIG. 8b]



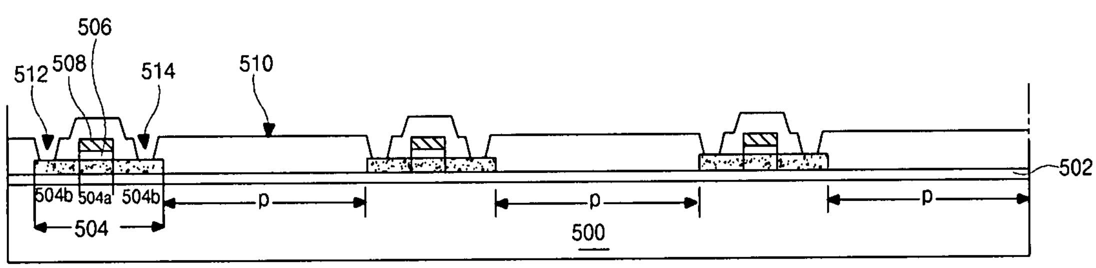
[FIG. 8c]



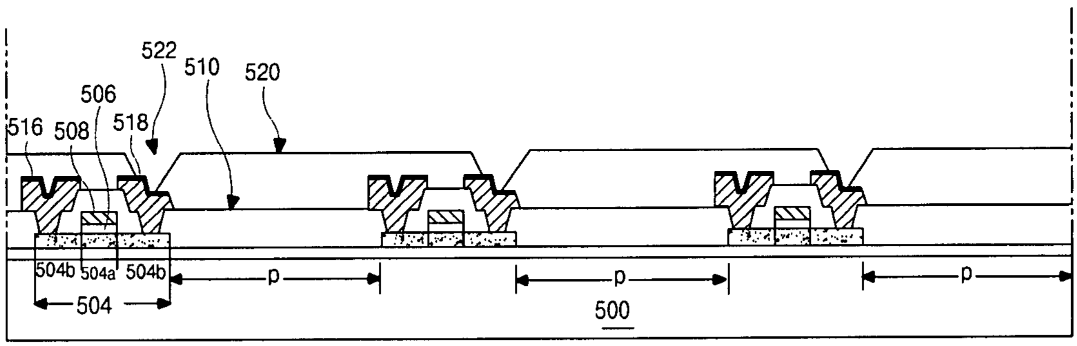
[FIG. 9]



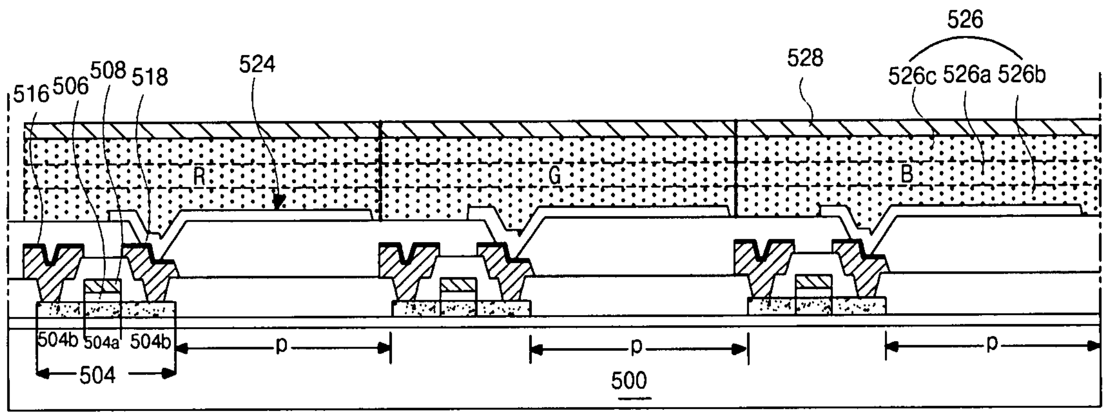
[FIG. 10a]



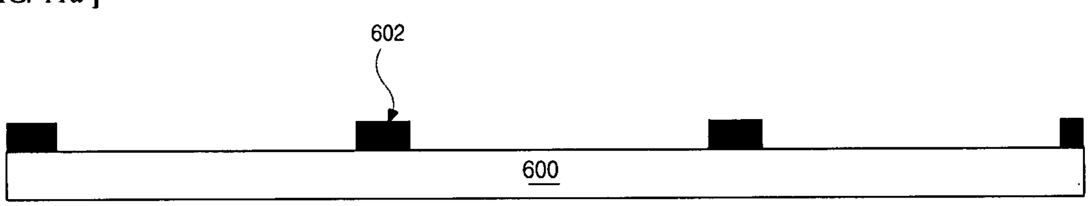
[FIG. 10b]



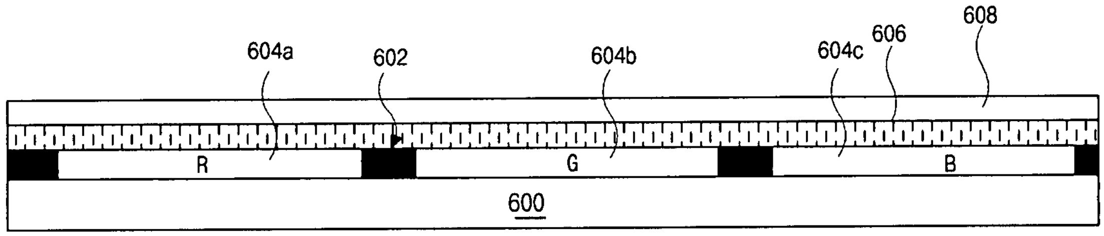
[FIG. 10c]



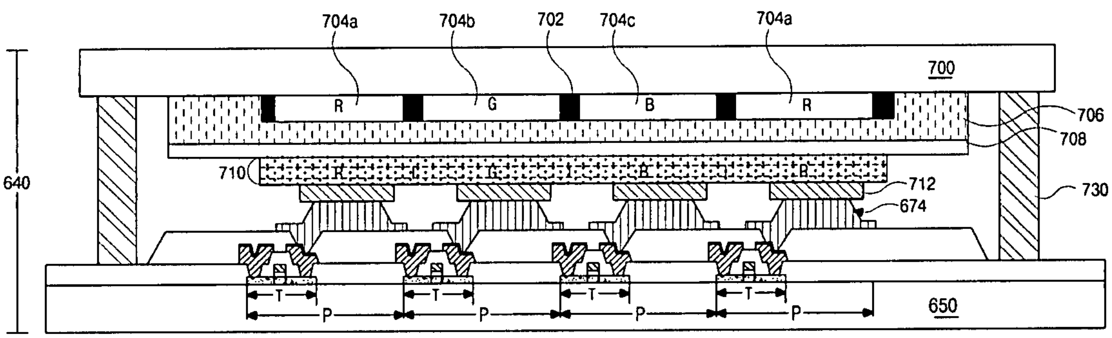
[FIG. 11a]



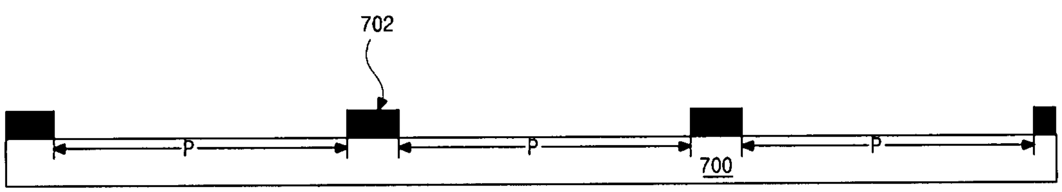
[FIG. 11b]



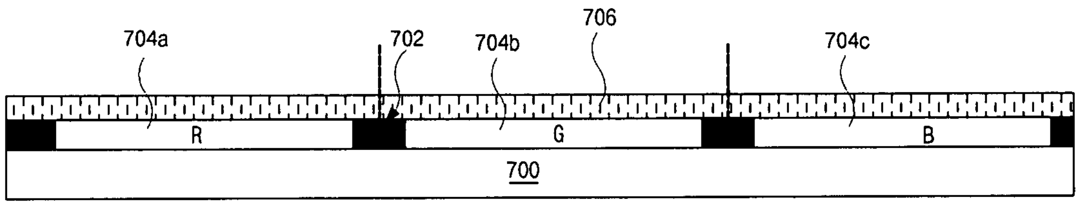
[FIG. 12]



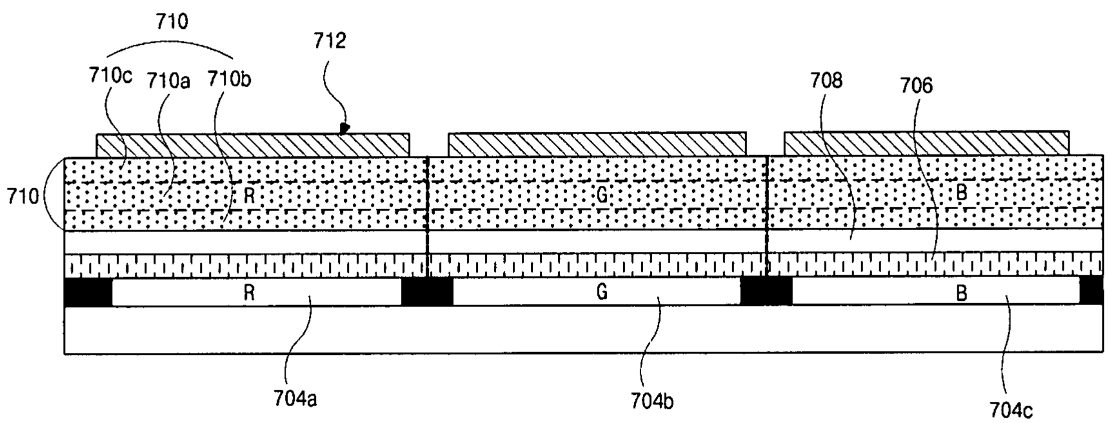
[FIG. 13a]



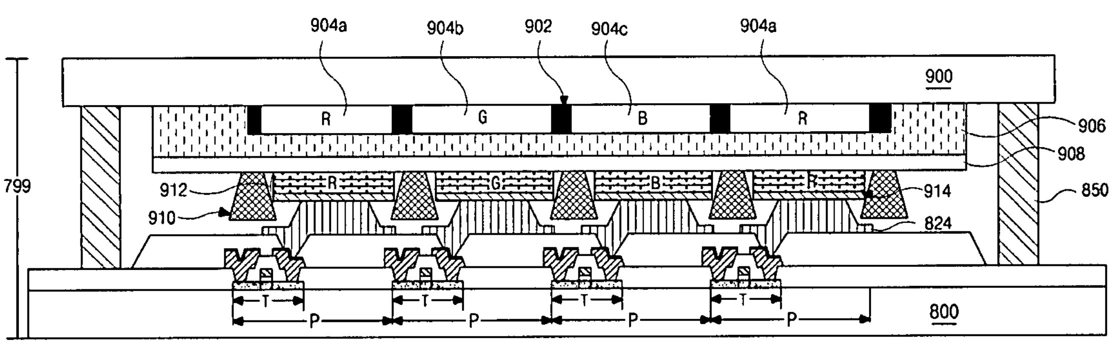
[FIG. 13b]

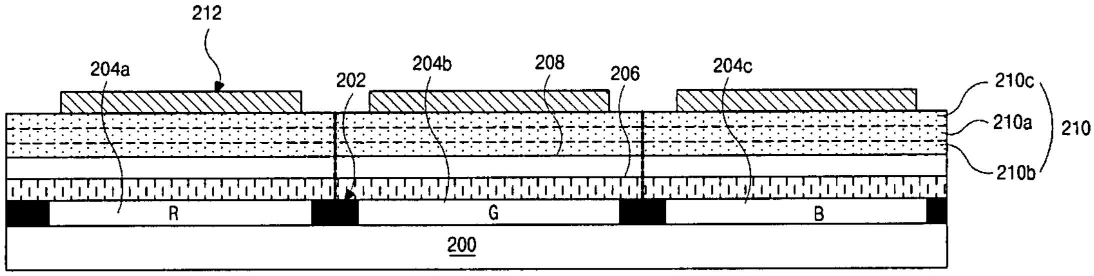


[FIG. 13c]

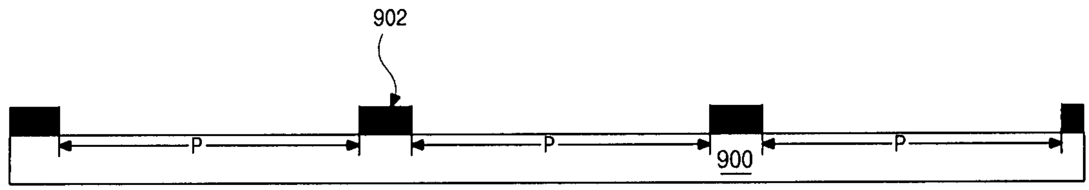


[FIG. 14]

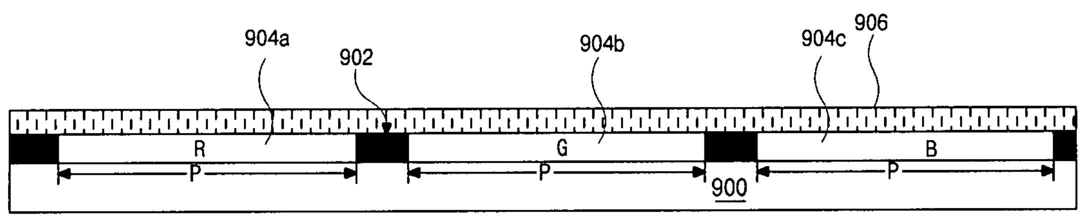



212
204a
202
204b
208
206
204c
210c
210a
210
210b
R
G
B
200

[FIG. 15a]



[FIG. 15b]



[FIG. 15c]